Forest Health Protection
Pacific Northwest Region
USDA Forest Service

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

Forest Health Highlights in Washington—2009

Washington State Department of Natural Resources
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Front cover: 2009 Douglas-fir tussock moth defoliation near Palmer Lake in Okanogan County.

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Summary

Washington has nearly 22 million acres of forestland. In 2009, over 1.73 million acres of this land contained elevated levels of tree mortality, tree defoliation, or foliar diseases. This is an increase from the 1.36 million acres reported in 2008. Similar levels of damage were observed in 2006. Previous annual totals were:

2007: 1.4 million acres **2006**: 1.9 million acres **2005**: 1.5 million acres

Drought conditions and warm, dry spring weather tend to increase tree stress and insect success, driving acres of damage up. 2009 was an abnormally dry year for eastern Washington with moderate drought conditions in north central Washington. Areas with major wildfires in 2006 that were not surveyed since these events, temporarily decreasing acres of damage, are now being surveyed again.

Almost 6.4 million trees were recorded as recently killed.

Defoliation by the **Douglas-fir tussock moth** increased to more than 3,500 acres in 2009 from 300 acres in 2008. The outbreak covers numerous discrete areas east and west of Oroville in northern Okanogan County. A buildup of parasites and virus in the tussock moth population may slow the expansion of defoliated acres in the Oroville area in 2010. Very light defoliation and egg masses have been observed in the Methow Valley.

In western Washington, there were almost 33,000 acres with **Douglas-fir beetle-**killed trees in 2009. This is the highest number of acres that has been recorded in western Washington in three decades of aerial survey data collection. Douglas-fir beetle breeding in large amounts of windthrown Douglas-fir trees from recent windstorms is likely contributing to their increased population. Statewide, there were 80,000 acres with Douglas-fir beetle caused mortality.

The area affected by **western spruce budworm** defoliation in 2009 decreased only slightly to 412,000 acres from 451,000 acres in 2008. Defoliation continues to be widespread along the eastern slopes of the North Cascades in western Kittitas County, Chelan County, and Okanogan County. As predicted by an increase in pheromone trap catches, the area of defoliation has expanded in northeastern Washington (eastern Okanogan County and western Ferry County). A previous outbreak in the Mt. Adams area and northwestern Yakima County has almost completely subsided.

Pine bark beetle activity continues across eastern Washington where almost 420,000 acres of forest lands were observed with some current beetle-kill. Elevated levels of mortality were observed east of North Cascades National Park extending into the Loomis State Forest, on mountain ranges east and west of Lake Chelan, in mountainous areas of Ferry, Stevens, and Pend Oreille Counties, in the upper Yakama Indian Reservation, and in the Naches River watershed area. Smaller areas of pine bark beetle activity are scattered across Spokane County and the lower tree line forests of Klickitat County.

Weather and Forest Health

Glenn Kohler, Washington DNR

Figure 1. Flood damaged Douglas-firs in western Washington killed by Douglas-fir beetle.

Severe weather events that injure or kill trees often make them more susceptible to attack by insects and pathogens. Examples include windthrow, winter damage (defoliation, cracks or breakage from cold, snow or ice), heat stress, flooding, landslides and hail. Many insects and pathogens use weakened or dead trees to maintain and sometimes increase their populations. Injuries can be vulnerable to infection by fungi. Outbreaks of certain bark beetle species, such as Douglas-fir beetle, follow weather or fire events that kill or injure numerous trees. Unusually wet spring weather can increase the incidence of foliar diseases.

Aerial surveys aim to record the location and severity of weather related events, giving landowners and managers warning to take appropriate action, such as salvaging weakened or dead material.

Vigor and resilience to adverse weather can be increased by ensuring that trees have room to grow and are appropriate species for the site. For example, forests in eastern Washington are generally overstocked with too much fir and not enough drought tolerant pine and larch. These conditions favor defoliators such as the western spruce budworm and perpetuate root disease and bark beetle activity. Swiss needle cast disease affects Douglas-fir growing on coastal sites that may be more suited to western hemlock and Sitka spruce.

Glenn Kohler, Washington DNR

Figure 2. Thinned ponderosa pine stand north of Ellensburg.

Drought

Temperatures statewide in July 2009 were well above normal. Some areas of western Washington experienced the highest temperatures ever recorded, for example, 103 degrees in Seattle on July 29th. This heat wave lasted about five days, resulting in wilting symptoms in western red cedar and scorched leaves on bigleaf maples in western Washington. Parts of western Washington were abnormally dry for most of 2009 and moderate to severe drought conditions were reported for the Olympic Peninsula in September and October. North central Washington experienced moderate drought for most of 2009 and severe drought since September 2009. Some areas of eastern Washington received below normal summer precipitation from 2005 to 2008. Trees experiencing drought stress in these areas become more susceptible to insect and disease attacks and are less likely to recover from damage. In eastern Washington, trees growing in dense or overstocked stands have a higher likelihood of experiencing drought stress.

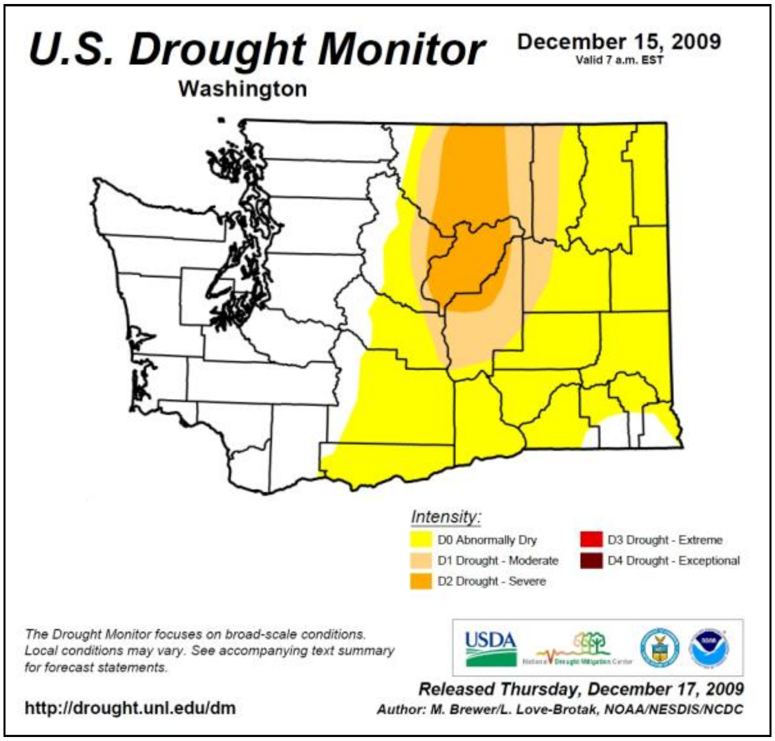


Figure 3. Washington Drought Monitor for December 15, 2009. *Source: National Drought Mitigation Center (USDA & NOAA).*

Fire

The 2009 fire season in Washington was below normal in terms of acres burned. The acreage burned in DNR jurisdiction was 17,203, which was 45% below average and similar to 2008. Due to high temperatures and low precipitation, fire danger was highest during late July and early August. Low fuel moistures increased the risk of large fires several weeks earlier than normal in interior western and eastern Washington. An unusually high number of lightning strikes contributed to an above average number of fire starts (1,045) in 2009. The number of large lightning caused fires was low due to precipitation associated with most lightning events and a lack of high winds. The Washington Department of Natural Resources suppressed 96% of wildfires when they were 10 acres or less.

Aerial Survey

G. Kohler, Washington DNR

Figure 4. Partenavia aircraft used for aerial survey in Washington State.

The aerial survey reported on here is flown at 90-120 mph at approximately 1,500 feet above ground level. Two observers (one on each side of the airplane) look out over two-mile swaths of forestland and mark on a digital sketchmapping computer any recently killed or defoliated trees they see. They then record a code for the agent that likely caused the damage (inferred from the size and species of trees and the pattern or "signature" of the damage) and the number of trees affected. Photos are rarely taken. It is very challenging to accurately identify and record damage observations at this large scale. Mistakes occur, but our goal is to correctly identify and accurately indicate damage within ¼ mile of the actual location at least 70% of the time.

On the other hand, we have been obtaining increasingly helpful background imagery for our sketchmaper system. Newer satellite photography showing recent management activity allows observers to place the damage polygons more accurately. In addition, aerial observers are familiar with forestry and forest pests and are trained to recognize various pest signatures. There is always at least one observer in the plane who has three or more years of sketchmapping experience.

Each damage area (polygon) is assigned a code for the damage agent. These codes are defined in the legend of the aerial survey maps. The agent code is followed by number of trees affected, number of trees per acre affected, or intensity of damage (L-Light, M-Moderate, H-Heavy). If more than one agent are present in a polygon, multiple listed codes are separated by an exclamation point (!). When interpreting data and maps, do not assume that the mortality agent polygons indicate total mortality within the area. Depending on the agent that is active, only a small proportion of trees in the polygon may actually be recently killed.

Areas burned by wildfire are not mapped until the second year following the fire. From the air it is difficult to distinguish mortality caused directly by the fire from local mortality caused by insects or disease. After a year has passed, the direct effects of the fire have mostly subsided and pests are credited with the newest tree damage.

The actual amount of annual damage from tree diseases and dwarf mistletoes is underestimated by aerial survey mapping. Symptoms of these agents are difficult to see from the air. Disease and chronic dwarf mistletoe infections may lead to mortality from other causes, such as bark beetles, which is recorded in subsequent years of aerial survey.

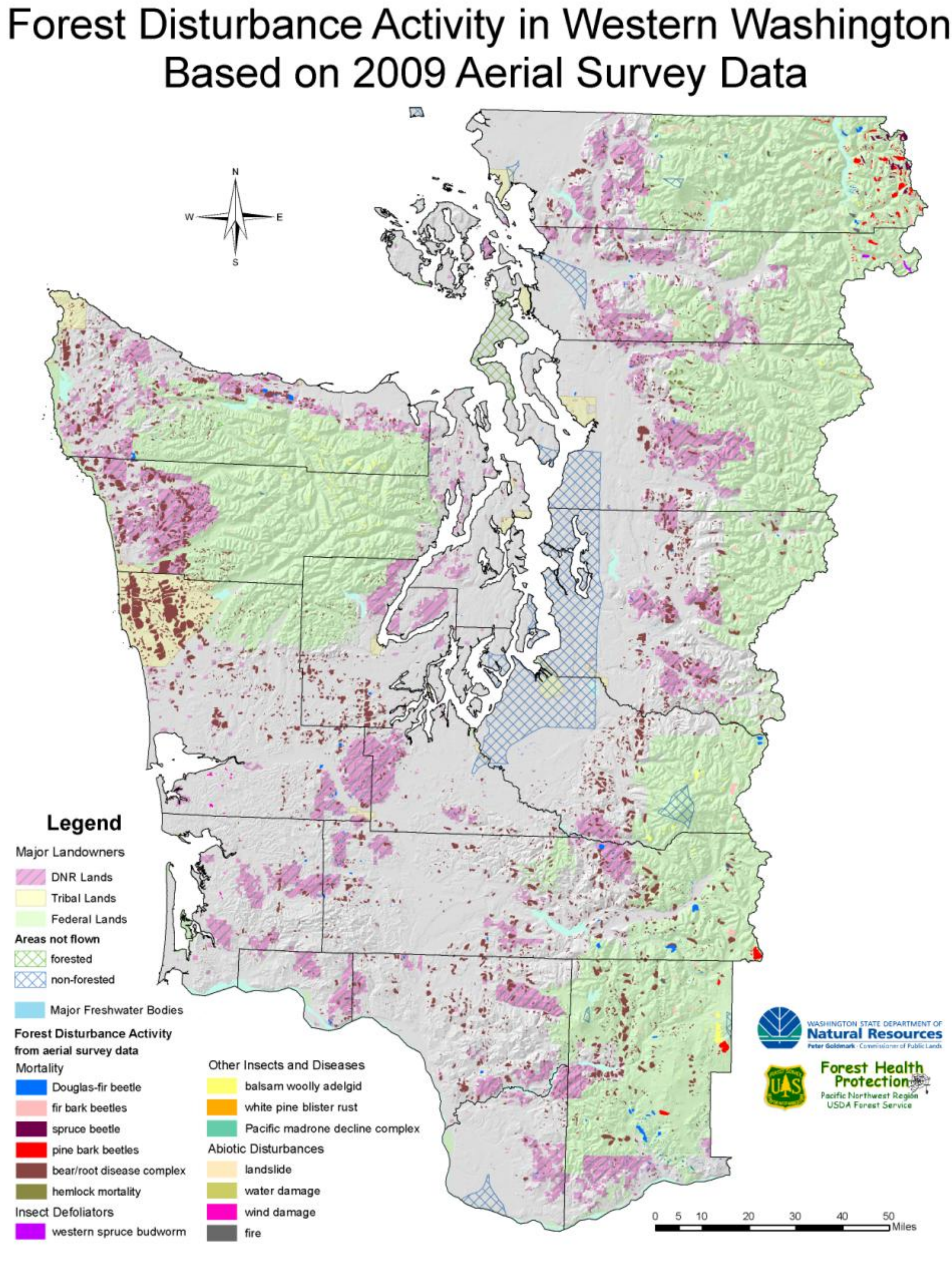


Figure 5. Forest disturbance map of Western Washington composed from 2009 aerial survey data.

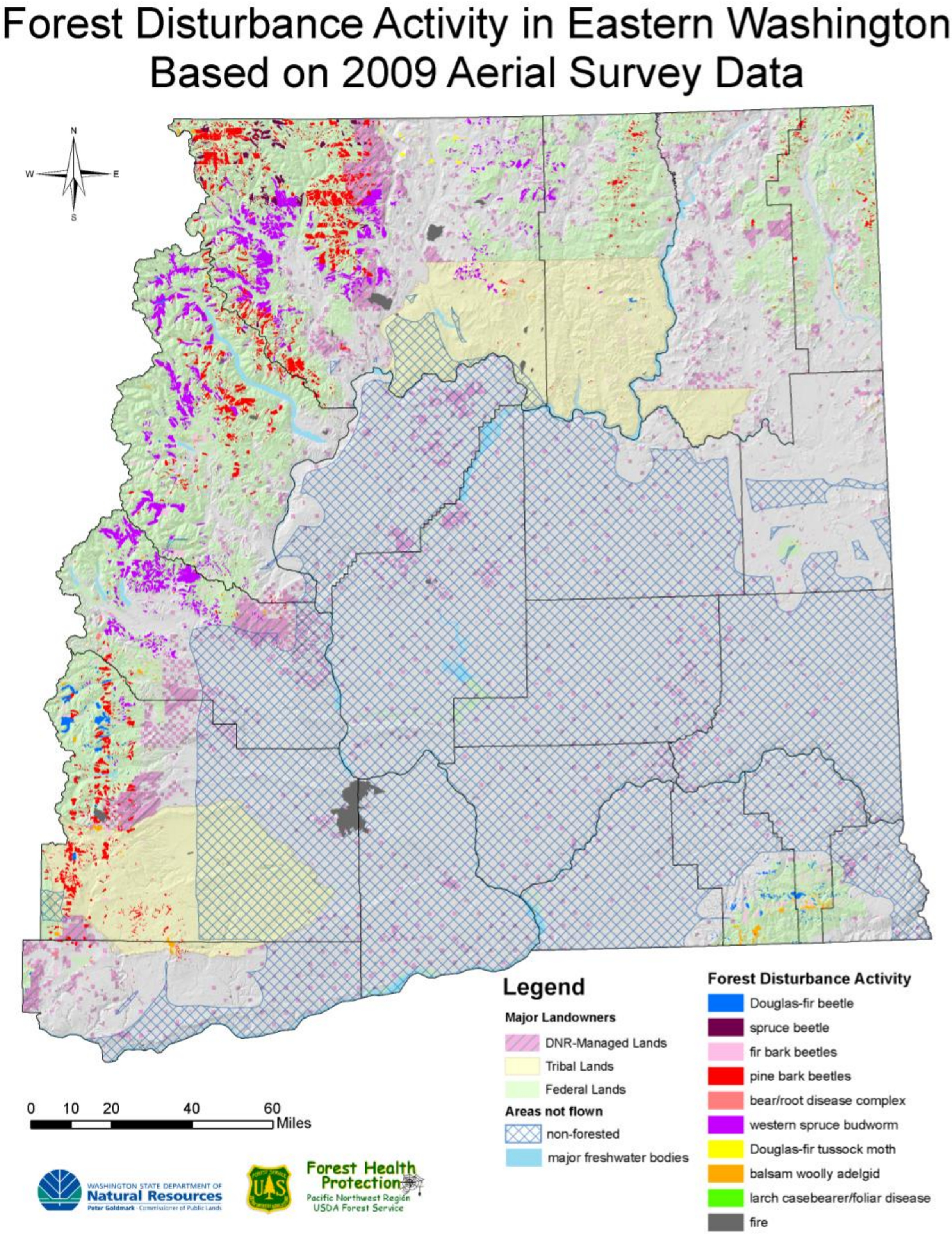


Figure 6. Forest disturbance map of Eastern Washington composed from 2009 aerial survey data.

Insects

Bark Beetles

Fir Engraver (*Scolytus ventralis* Le-Conte)

Glenn Kohler, Washington DNR

Figure 7. Fir engraver caused mortality of grand fir in central Washington.

Approximately 157,000 acres with fir engraver mortality were recorded in 2009, continuing a downward trend in recent years. Areas with scattered individual tree mortality were most commonly recorded with an average of slightly over one tree killed per acre. This is a typical pattern during non-outbreak years as fir engravers preferentially attack firs under stress from defoliators, disease, or environmental conditions. Fir engraver-killed trees were common in areas that have experienced several years of defoliation by western spruce budworm, such as northwest Yakima County, Kittitas County, and south Chelan County. High insect populations were probably offset by the near normal rainfall during the summer months. Severe drought conditions can lead to outbreaks of fir engraver over larger areas. Adequate moisture allows trees to defend themselves from beetle attack.

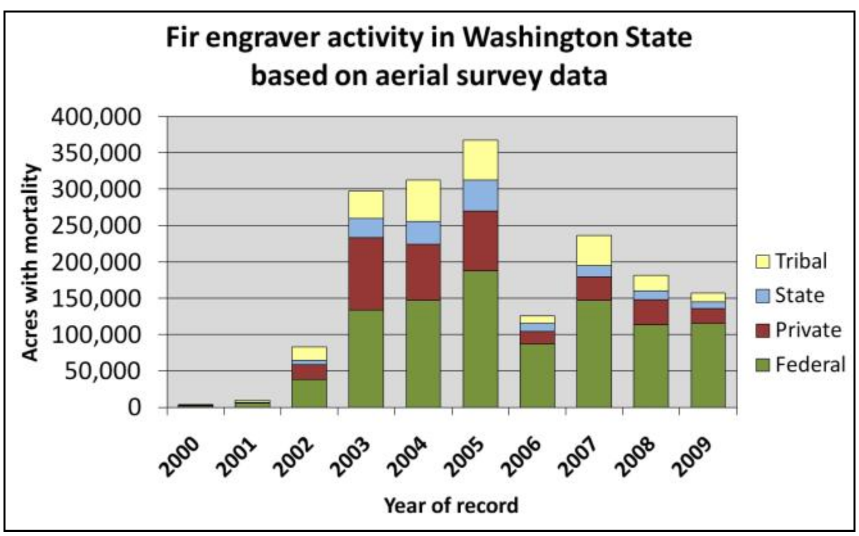


Figure 8. Ten year trend for total acres affected by fir engraver in Washington.

Ogden Archive, USDA Forest Service

Figure 9. Fir engraver galleries etched in sapwood.

Douglas-fir Beetle (*Dendroctonus pseudotsugae* Hopkins)

Glenn Kohler, Washington DNR

Figure 10. Groups of mature Douglas-fir killed by Douglas-fir beetle in western Washington in 2009.

Statewide, approximately 80,000 acres with Douglas-fir beetle (DFB) caused mortality were recorded in 2009. This is more than a doubling from 37,000 acres in 2008 and above average for recent years of record. Contributing to this increase is a dramatic rise in the number of DFB-killed trees in western Washington, where almost 33,000 acres with DFB-killed trees were recorded in 2009. This is the highest number of acres recorded in western Washington in three decades of aerial survey data collection. Douglas-fir beetle breeding in large amounts of windthrown Douglas-fir trees from the winter windstorm of 2006 is likely contributing to their increased population. Damage from another windstorm in winter of 2007 will likely perpetuate DFB caused mortality in western Washington in 2010. East of the Cascade Mountains, DFB activity appears to be increasing in northwest Yakima County and northern Pend Oreille County. The areas of DFB activity in Yakima County are in forests that were heavily defoliated by western spruce budworm in 2005 and 2006. Elevated DFB activity continues in the Blue Mountains where increases in some areas in 2008 and 2009 may be a result of trees injured in the Columbia Complex fire of 2006.

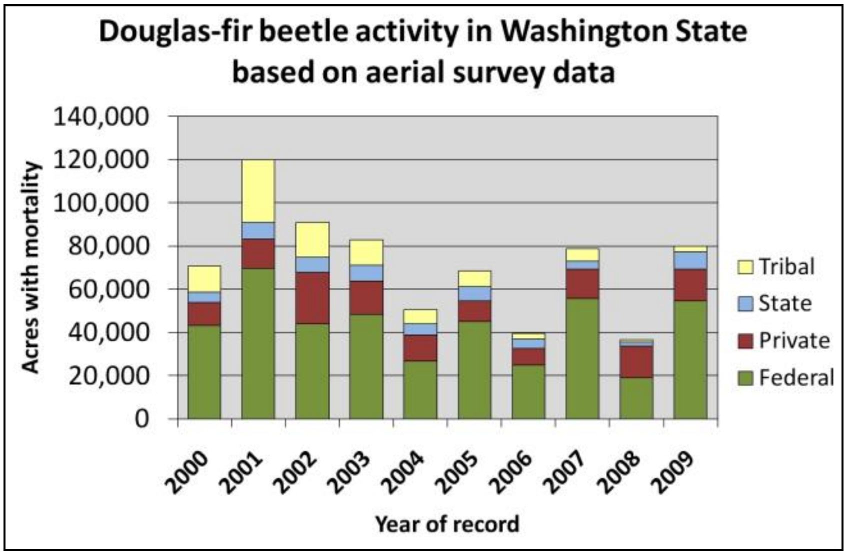


Figure 11. Ten year trend for total acres affected by Douglas-fir beetle in Washington.

USDA Forest Service

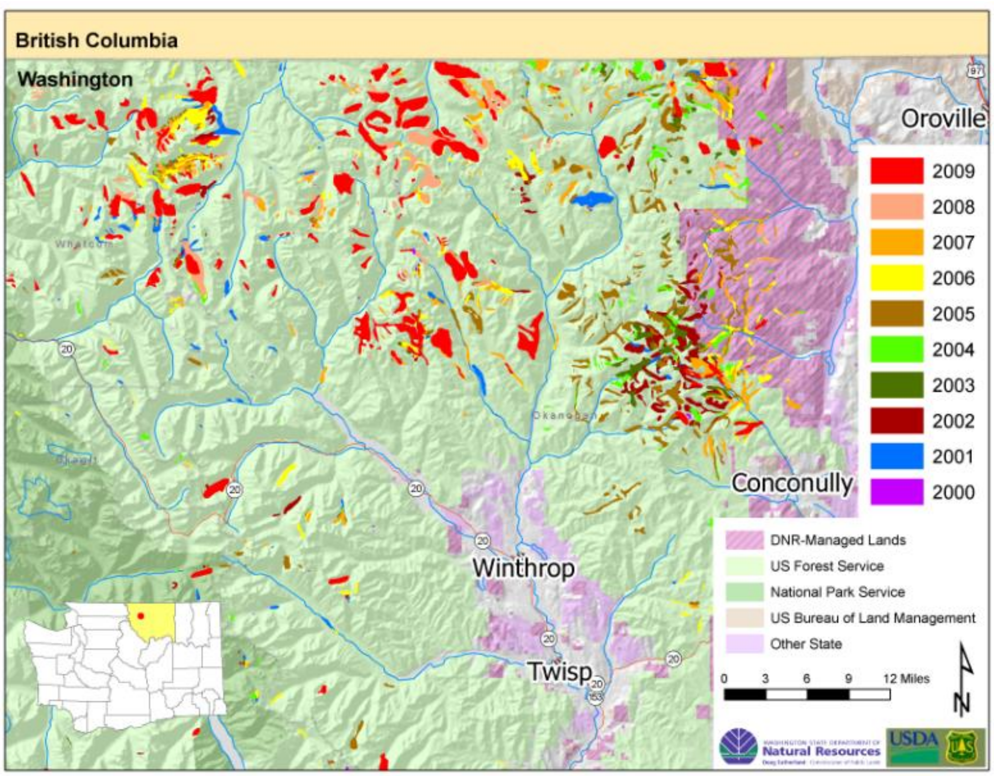
Figure 12. Egg and larval galleries of Douglas-fir beetle.

Spruce Beetle
(*Dendroctonus rufipennis* Kirby)

Mike Johnson, Washington DNR

Figure 13. Bark flaked off Engelmann spruce by woodpeckers feeding on spruce beetle.

High elevation stream bottom stands of Engelmann spruce near the Cascade crest in Okanogan County continue to be affected by ongoing spruce beetle mortality (Figure 14). 56,000 acres in this area were observed with some spruce beetle-kill in 2009. This is a two-fold increase from 2008 (24,000 acres) and the highest number of acres recorded in the last ten years. This outbreak began in 1999 following winter damage to host trees. Below normal precipitation in the Okanogan area in recent years has increased tree stress in dense stands, sustaining the outbreak. Much of the affected area is adjacent to or in areas burned in the past decade. Spruce beetle may also be increasing its population in fire damaged trees.



Previous annual total acres with spruce beetle mortality:

2008: 24,000
2007: 30,000
2006: 31,000
2005: 40,000
2004: 23,000

Figure 14. Ten years of spruce beetle caused mortality in northwestern Okanogan and neighboring counties.

Pine Bark Beetles (*Dendroctonus ponderosae* Hopkins, *Dendroctonus brevicomis* LeConte, & *Ips* spp.)

Amy Ramsey-Kroll, Washington DNR

Figure 15. Mountain pine beetle-killed ponderosa pine (orange) and lodgepole pine (red) in central Washington.

Nearly 420,000 acres of forest lands were observed with some current bark beetle-killed pine trees. Activity is increasing throughout much of the northeastern part of the state. Elevated levels of mortality were observed east of North Cascades National Park extending into the Loomis State Forest, on mountain ranges east and west of Lake Chelan, in mountainous areas of Ferry, Stevens, and Pend Oreille Counties, in the upper Yakama Indian Reservation, and in the Naches River watershed area. Smaller areas of pine bark beetle activity are scattered across Spokane County and the lower tree line forests of Klickitat County. The most notable increase in 2009 was in Okanogan County where approximately 190,000 acres with pine bark beetle caused mortality were mapped, nearly triple the number in 2008 (65,000 acres). Much of this increase is due to resumption of surveying within the boundaries of the 175,000 acre Tripod Complex and 54,000 acre Tatoosh fires, areas that have not been thoroughly surveyed since they burned in 2006. It is also likely pine beetles have increased their population in fire damaged trees and have attacked nearby host trees. The number of acres with mortality in Ferry County increased to approximately 14,000 acres in 2009 from 8,000 in 2008.

Glenn Kohler, Washington DNR

Figure 16. Western white pine killed by *Ips montanus*.

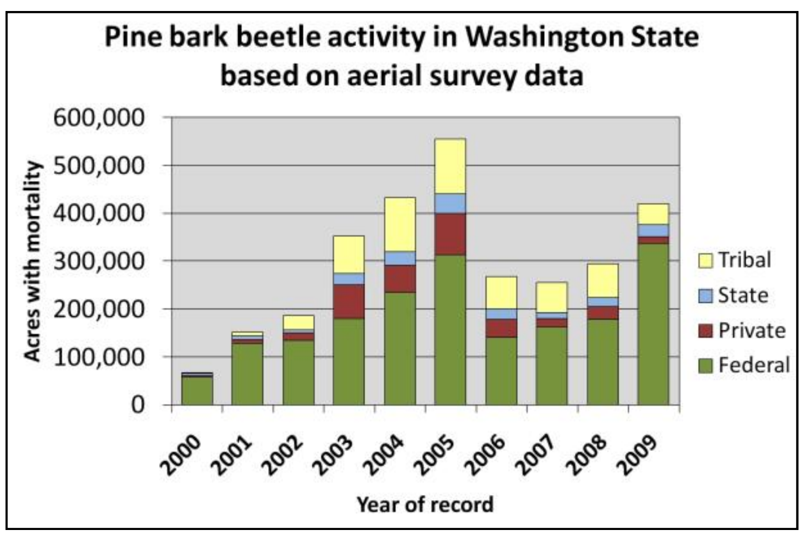


Figure 17. Ten year trend for total acres affected by pine bark beetles in Washington.

Defoliators

Western Spruce Budworm (*Choristoneura occidentalis* Freeman)

The east slopes of the Washington Cascade Mountains continue to experience large areas of western spruce budworm (WSBW) defoliation. Areas with WSBW defoliation recorded in the 2009 aerial survey have decreased only slightly to 412,000 acres, down from 451,000 acres in 2008, and remain below a recent peak of 556,000 acres defoliated in 2006. The affected area is still above the ten year average WSBW defoliated area of 317,000 acres. Defoliation continues to be widespread along the eastern slopes of the North Cascades in western Kittitas County, Chelan County, and Okanogan County. WSBW pheromone trap counts in central and eastern Okanogan County and northern Ferry County have been elevated during 2007 to 2009. Correspondingly, the acres of WSBW defoliation recorded in eastern Okanogan County and northern Ferry County have increased in 2009. In addition, trap counts also remain high in Kittitas County where defoliation is likely to continue (Figure 21).

A previous outbreak with heavy defoliation in 2005 and 2006 in the Mt. Adams area and northwestern Yakima County has almost completely subsided.

Jeff Jones, American Forest Land Co., LLC

Figure 18. 2009 western spruce budworm defoliation in the Teanaway watershed.

Robert Backman, Washington DNR

Figure 19. Last larval stage of western spruce budworm.

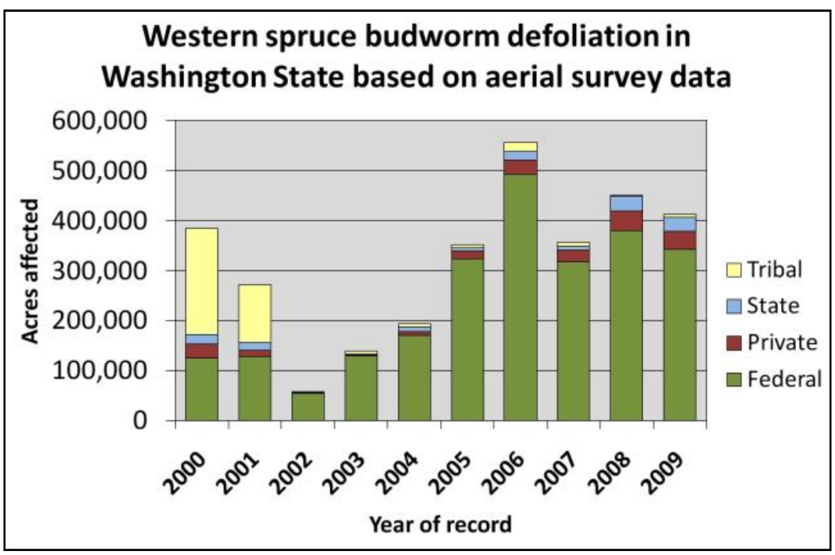


Figure 20. Ten year trend for total acres affected by western spruce budworm in Washington.

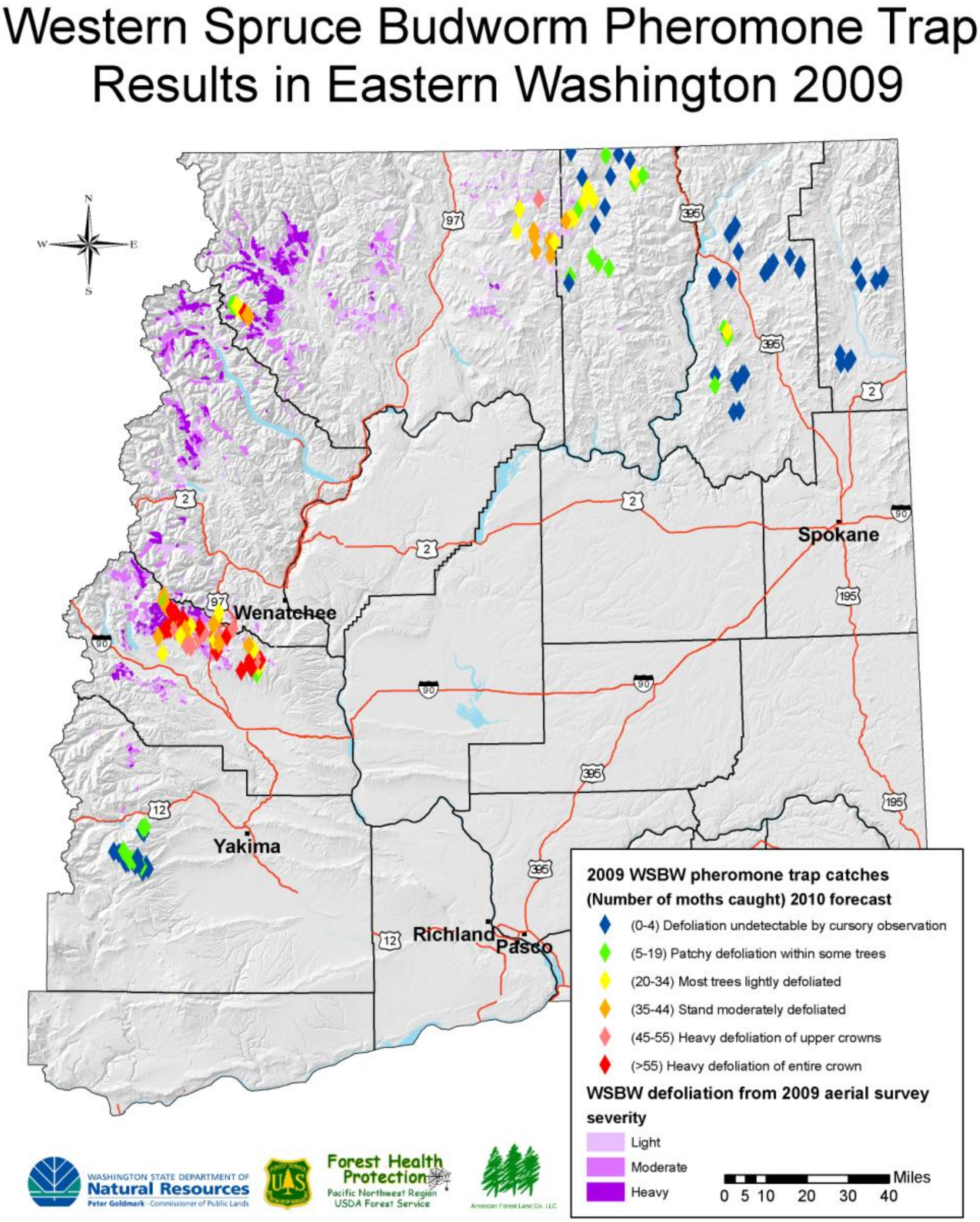


Figure 21. Western spruce budworm pheromone trap catch results for 2009 and defoliation detected by the 2009 aerial survey.

Douglas-fir Tussock Moth (*Orgyia pseudotsugata* McDunnough)

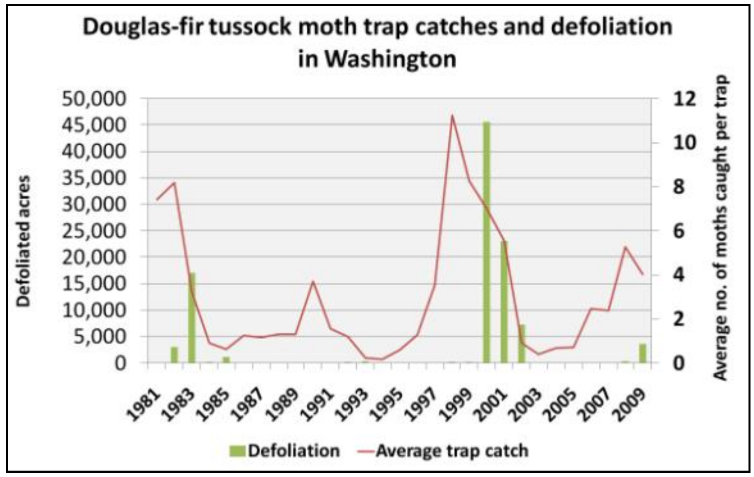


Figure 22. Correlation of DFTM pheromone trap catches with observed defoliation.

Defoliation by the Douglas-fir tussock moth (DFTM) increased to more than 3,500 acres in 2009 from 300 acres in 2008 (Figure 22). The outbreak covers numerous discrete areas east and west of Oroville in northern Okanogan County near the British Columbia border. Affected forests are mostly low elevation mixed stands of Douglas-fir, ponderosa pine, and western larch. The heaviest defoliation has occurred in dense stands of understory and immature trees. Western larch and ponderosa pine have also been heavily defoliated in some areas. In the Methow Valley, very light defoliation has been observed and low numbers of fresh egg masses are present.

Mike Johnson, Washington DNR

Figure 23. Symptoms of a naturally occurring virus in a Douglas-fir tussock moth caterpillar.

In 2009, DFTM caterpillars with symptoms of a naturally occurring virus and parasitized cocoons were common in heavily defoliated areas. A buildup of natural controls may slow the expansion of defoliation in those areas in 2010. However, some areas with light defoliation east of Oroville and in the Methow Valley have no or low levels of natural control apparent.

DFTM pheromone trap catches were elevated in western Okanogan County and along the Methow Valley, indicating that DFTM populations are still rising in that area. A few traps along the Idaho border in Spokane County have trended upward and some new defoliation was reported at Tekoa Mountain. The Idaho Department of Lands has reported increased DFTM populations in areas south of Coeur d'Alene.

Glenn Kohler, Washington DNR

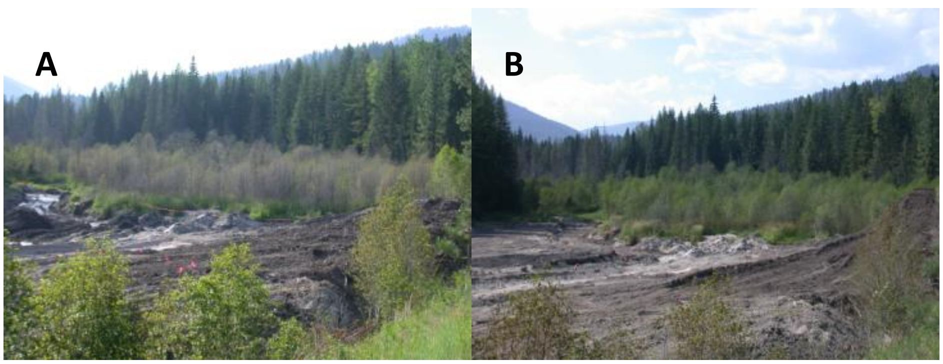
Figure 24. Heavy defoliation by Douglas-fir tussock moth near Oroville in 2009.

Forest Tent Caterpillar (*Malacosoma disstria* Hübner)

The 2009 aerial survey observed tent caterpillar in alder on 234 acres along stream bottoms in south Stevens County. Ground observers reported defoliation in red alder and other hardwoods along riparian areas throughout central Stevens County and north of Ellensburg in Kittitas County. Washington DNR entomologists identified forest tent caterpillar (FTC) as the cause of damage in some of these areas. Defoliation by FTC in both areas of central and northeast Washington was noticed in early July and damaged trees had refoliated by October.

Mike Johnson, Washington DNR

Figure 25. Forest tent caterpillar larva feeding on red alder in northeast Washington.



Mike Johnson, Washington DNR

Figure 26. Forest tent caterpillar defoliation of red alder in northeast Washington in July 2009 (A) and re-foliation of the same stand in October 2009

Larch Casebearer (*Coleophora laricella* Hübner) NON-NATIVE

Larch casebearer damage was observed on 216 acres in 2009 in north Ferry County and near the Idaho border north and south of Newport. This is a significant decrease from the more than 70,000 acres defoliated in 2008.

Gypsy Moth (*Lymantria dispar* Linnaeus) NON-NATIVE

In 2009, the Washington State Department of Agriculture placed 23,213 gypsy moth pheromone traps in Washington. Eighteen European gypsy moths were collected from seven catch areas, all in western Washington. No Asian gypsy moths have been trapped in Washington since 1999. A total catch of 18 moths is not unusually high from a trapping effort of this size. No eradication projects were conducted in 2009 and none are planned for 2010 at this time.

Washington Dept. Agriculture

Figure 27. Gypsy moth trap.

Branch and Terminal Insects

Balsam Woolly Adelgid (*Adelges piceae* Ratzeburg) NON-NATIVE

Balsam woolly adelgid (BWA) is an exotic insect that impacts subalpine fir , grand fir and Pacific silver fir. In 2009, the aerial survey recorded 69,000 acres with balsam woolly adelgid (BWA) damage in Washington. Approximately 5,500 acres were damaged by BWA in high elevations of the Okanogan Highlands in eastern Okanogan, Ferry, Stevens, Pend Oreille, and northern Spokane Counties. Damage of this extent has not been previously observed in this area. BWA damage was also recorded at high elevations of the Blue Mountains, the east slopes of the Olympic Mountains, and the high elevation forests of the Cascade Mountains. BWA damage observed in the Washington aerial survey has been consistently high since 2001, averaging more than 43,000 acres per year for the past nine years.

Ladd Livingston, Idaho Department of Lands

Figure 28. Swelling (gouting) around buds and branch nodes caused by BWA.

It is challenging to detect balsam woolly adelgid infestations and mortality with aerial survey techniques, but surveyors have had good success identifying affected trees based on dark colored arboreal lichens that are more abundant and more visible when tree foliage is missing.

Ladd Livingston, Idaho Department of Lands

Figure 29. "Wool"-covered BWA females as they appear during summer.

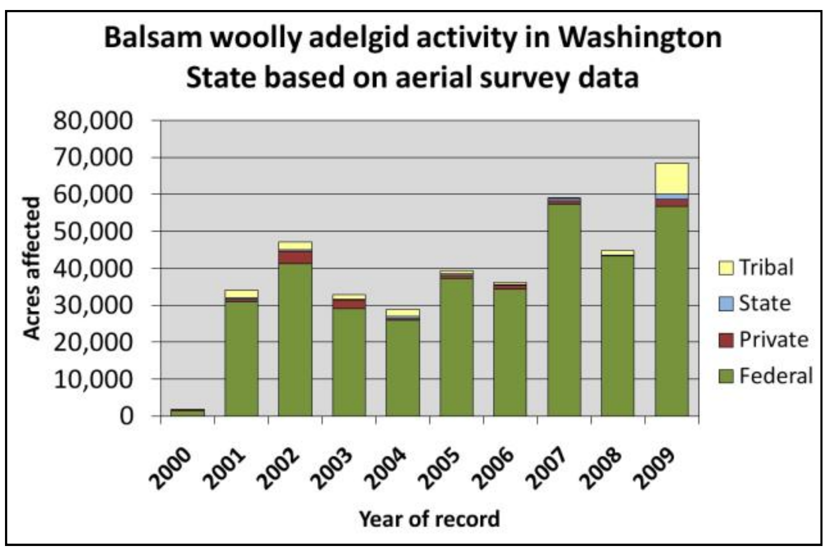


Figure 30. Ten year trend for total acres affected by balsam woolly adelgid in Washington.

Animals

Bear Damage / Root Disease

Aerial survey records scattered, pole sized, newly dead trees as "bear damage." Based on ground checking observations, this type of damage can be caused by bear girdling, root disease, drought stress, porcupine, or mountain beaver. Bear feeding activity is likely the primary mortality agent; however, ground truthing studies have shown that nearly half of this damage may be due to root disease.

Figure 31. Black bears damage trees during the spring by peeling the bark and eating the cambium.

Approximately 592,000 acres with bear damage mortality were observed in 2009, making this the most active year on record for Washington. The 310,000 acres recorded with bear damage in 2008 was also a record high at the time. The average number of trees killed per acre was actually lower in 2009 (1.54 TPA) than 2008 (2.39 TPA). Although the number of acres with damage nearly doubled from 2008 to 2009, the estimated total number of trees killed was just 26% higher in 2009 than 2008. The ten year average of acres with bear damage in Washington is 213,000.

Areas with bear damage mortality were widespread in low elevation forested areas of most western Washington counties with larger effects on the west side of the Olympic Peninsula.

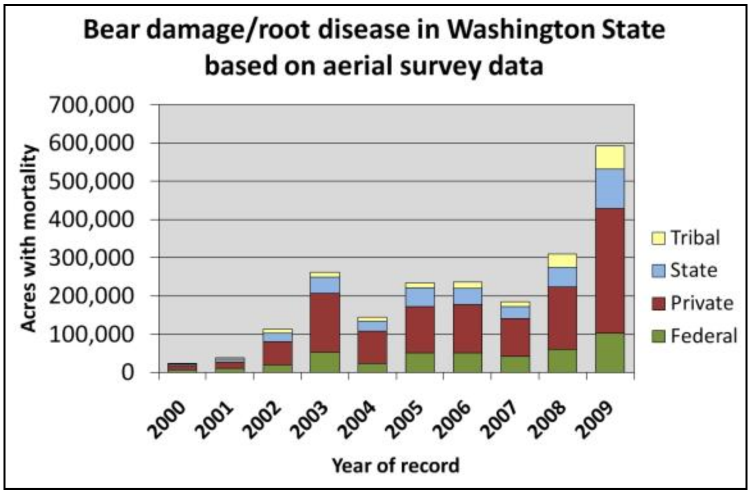


Figure 32. Ten year trend for acres affected by bear damage in Washington.

Abiotic Damage

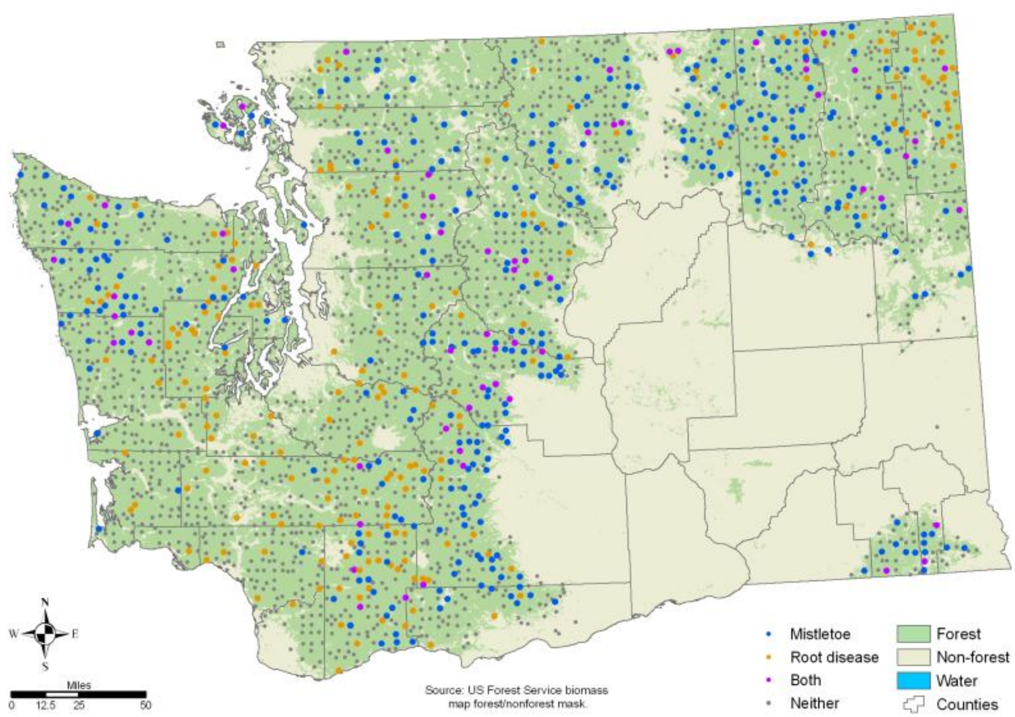
Wind

After two consecutive years with severe winter wind storms in western Washington, 2009 was a very quiet year for storm damage. Approximately 2,400 acres with new wind thrown trees were recorded statewide in 2009. This is less than one tenth the amount of wind damage generated by the severe winter storm of 2007 that was observed in 2008.

Forest Inventory

Forest health condition in Washington is monitored using aerial survey methods (see page 4 for more information) and ground-based methods. The USDA Forest Service Forest Inventory and Analysis (FIA) program measures and monitors Washington's forests for current forest condition, growth and trends using ground-based inventory methods. The FIA program is a national program that has been providing information about America's forests for over 75 years. FIA includes forest inventory, timber products output studies, a national woodland owner survey, and resource planning reporting. The Pacific Northwest FIA (http://www.fs.fed.us/pnw/fia/) determines the extent and condition of forest resources and analyzes how these resources change over time for all ownerships in Washington State. A network of several thousand permanent sampling plots (one per 6,000 acres of land) is the backbone of these forest inventory determinations. Other enhancements and techniques are also employed.

FIA data are very useful for quantifying tree mortality and damage that may be unobservable during aerial surveys. Dwarf mistletoes and diseases are underestimated using aerial survey methods, so ground-based surveys are necessary when trying to determine how many acres of forest land are affected by these agents. Statewide distribution of dwarf mistletoe and root disease incidence, based on FIA data, is illustrated in the map below (Figure 33).



Map created by : John M. Chase, US Forest Service, Pacific Northwest Research Station, Resource Monitoring and Assessment Program/ Forest Inventory and Analysis, Portland Oregon, 2009.

Figure 33. Root disease and dwarf mistletoe incidence on Forest Inventory and Analysis annual inventory plots in Washington, 2002-2008 (forest/nonforest geographic information system (GIS) layer: Blackard et al. 2008.)

Dwarf Mistletoes

Dwarf Mistletoe (*Arceuthobium* spp.)

Figure 34. Ponderosa pine with dwarf mistletoe .

Dwarf mistletoes are parasitic, flowering plants that grow on native conifers. There are ten different taxa of dwarf mistletoes in Washington and their distribution coincides with their host tree species range. They are obligate parasites that depend on the food produced by their host. Dwarf mistletoes can affect host trees by causing growth loss, growth deformities, mortality and predisposing trees to bark beetle attack. Brooms, or abnormal branching and clustering of branches and twigs, often form on infected trees. Dwarf mistletoe plants spread by emitting sticky seeds that fall onto other hosts or are carried from host to host on birds and small mammals. New infections are slow to develop, but are persistent.

Figure 35. Douglas-fir with dwarf mistletoe caused brooms (left and above).

Aerial survey does not detect dwarf mistletoe infections or impacts. In recent years a variety of USDA Forest Service FIA projects have used ground surveys and monitoring plots to assess dwarf mistletoe infection levels. (Figure 36). Forest are classified by “forest type”, named for the dominant tree species on the site. Douglas-fir, ponderosa pine, western hemlock, Pacific silver fir and western larch are the major dwarf mistletoe hosts in Washington.

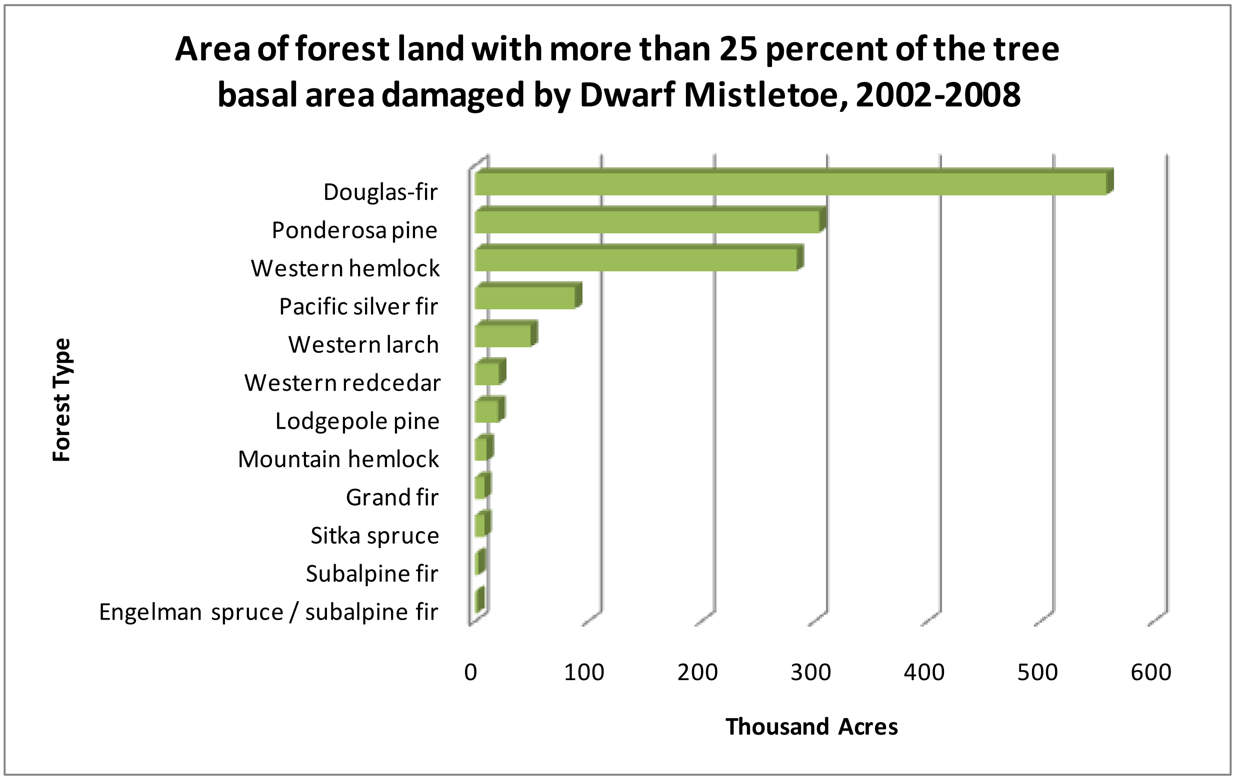


Figure 36. Forest types and acreage of dwarf mistletoe infected trees in Washington based on FIA data. Results are only reported if more than 25% of the tree basal area are damaged. Acreage damaged has been extrapolated from plot data.

In 2009, Washington DNR installed four dwarf mistletoe monitoring plots in ponderosa pine stands north of Ellensburg, WA. These plots will be used to monitor growth rates in host trees and monitor the spread of new dwarf mistletoe infections in thinned ponderosa pine stands over time.

Diseases

Cankers

White Pine Blister Rust (*Cronartium ribicola* Fisch.) NON-NATIVE

The causal organism of white pine blister rust, *Cronartium ribicola,* was introduced into western North America in 1910. All five-needle pines are susceptible to this exotic disease, including whitebark pine (*Pinus albicaulis* Engelm.) and western white pine (*Pinus monticola* Dougl. ex D. Don) in Washington. In 2009, 30,000 acres of whitebark pine mortality were observed throughout the high elevation mountainous areas of eastern Washington and a broad scattering of western white pine mortality was observed in northeast Washington. Although the aerial survey attributed this five-needle pine mortality to mountain pine beetle, white pine blister rust probably contributed to the observed mortality by increasing tree stress, predisposing them to attack from mountain pine beetles. The Washington aerial survey records very little area affected specifically by white pine blister rust (199 acres in 2009) because symptoms are difficult to distinguish from mountain pine beetle from the air.

Figure 37. White pine blister rust canker (yellowish target shaped area on main stem of tree).

Figure 38. White pine blister rust aeciospores on main stem of western white pine.

White pine blister rust has a complex life cycle, including five different spore forms, a multi-year cycle length and the requirement of two hosts for infection to occur. Until recently, the known hosts required for white pine blister rust infections in Washington were *Ribes* spp. and five-needle pines. In 2008, a graduate student at Oregon State University, Robin Mulvey, verified naturally occurring *C. ribicola* infections on *Pedicularis racemosa* Dougl. Ex Benth. in high elevation whitebark pine ecosystems at Mount Rainier National Park (personal communication, January 13, 2010).

A cooperative program between Washington DNR and the Dorena Genetic Resource Center of the USDA Forest Service began in 2007 and continued this year. The third generation of white pine blister rust resistant bred western white pine trees were planted across six different study sites in western Washington. All the sites were surveyed this year for mortality. White pine blister rust was present on three of the six sites, on less than 0.5% of trees.

Figure 39. Western white pine seedling.

Root Diseases

Root diseases have a significant role in forest change in Washington. The most important root diseases in Washington are Annosum root disease, Armillaria root disease and laminated root rot. They can affect many different species of trees, cause tree mortality and growth loss and promote diverse stand structure and habitat conditions. Trees with root disease can often be predisposed to attacks from bark beetles.

The annual aerial survey underestimates the number of acres affected by root disease, but bark beetle mortality and bear damage, both recorded annually, are sometimes associated with root disease infested areas. In recent years, a variety of USDA Forest Service FIA projects have used ground surveys to assess root disease infection levels (Figure 40). Forests are classified by “forest type”, named for the dominant tree species on the site.

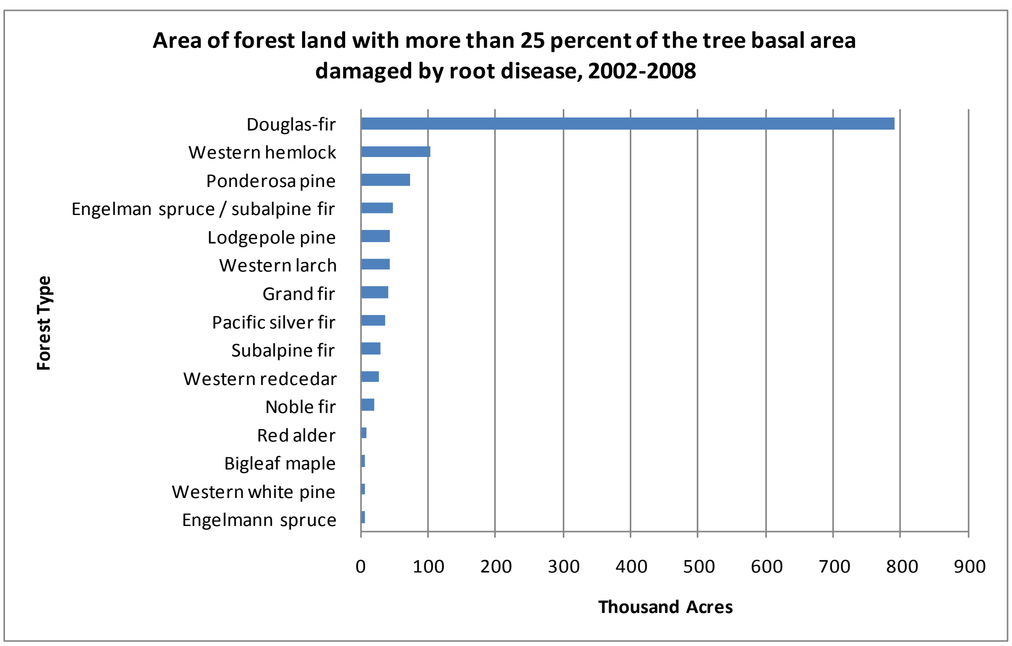


Figure 40. Forest types and acreage of root disease infected trees in Washington based on FIA data. Results are only reported if more than 25% of the tree basal area are damaged. Acreage damaged has been extrapolated from plot data.

Annosum Root Disease (*Heterobasidion annosum* (Fr.) Bref.)

Heterobasidion annosum causes root and butt decay and can cause tree mortality in hosts. Most conifers in Washington are hosts, but susceptibility and damage depends on tree species and location. Trees with Annosum root disease are subject to windthrow and basal stem breakage. New infections can occur through root to root contact between infected and healthy trees and through spore deposition and germination on wounds and freshly cut stumps.

Amy Ramsey-Kroll, Washington DNR

Figure 41. Western hemlock stand with Annosum root disease, Olympic Peninsula study area.

In fall, 2008, we conducted a study on the Olympic Peninsula examining the effects of variable density thinning on mortality and windthrow in western hemlock stands infested with *H. annosum*. In 2003-2005 the stand was thinned to an average basal area of 200 square feet per acre. Patch cuts, or small clear-cut areas, were scattered throughout this stand and were an average of 0.47 acres in size. A major windstorm occurred in December 2007. Trees that had blown over, were leaning, or had a broken stem were considered wind damaged.

Glenn Kohler, Washington DNR

Figure 42. Windthrow in Olympic Peninsula western hemlock study area. Bark beetle monitoring was also conducted in this study area, notice the insect traps.

The number of wind damaged trees in the thinned stands were compared to adjacent unthinned stands. There was no significant difference in wind damaged trees between the two conditions. The unthinned stand, with an average basal area of 278 square feet per acre, had 4% wind damage and the thinned stand had 6% wind damage. In both the thinned and unthinned stands, 46% of the wind damaged trees had signs of Annosum root disease. Wind damage associated with the patch cuts was considerably greater than in the rest of the thinned stand. An average of 54 trees were wind damaged within 100 feet of a patch cut while an average of 17 trees were wind damaged in equivalent size areas in the thinned portions. 12% of the trees wind damaged within 100 feet of a patch cut had signs of Annosum root disease. A formal report with the results of this study will be available in late spring, 2010. Please contact us if you are interested in receiving a copy.

In 2009, we installed three 0.5-acre conifer susceptibility trial plots near Glenwood, WA. Douglas-fir, ponderosa pine, western larch and western white pine were planted in *Armillaria* and Annosum root disease patches in efforts to determine species susceptibility to the root diseases. We also identified standing ponderosa pine trees in the area with either *Armillaria* or Annosum root disease. In 2010 we will plant Douglas-fir, ponderosa pine, western larch and western white pine around the bases of infected trees and monitor survival over time. Our objective with these plots is to inform management options for land managers in the area who are replanting harvested or thinned root disease infested stands.

Armillaria Root Disease (*Armillaria* spp.)

Both conifer and hardwood trees in Washington are susceptible to *Armillaria* root disease. There are many plant species that can be infected and there are many species of *Armillaria* that can infect. The *Armillaria* species on the western side of the Cascade Mountains of Washington are generally less aggressive saprophytic decomposers that only kill trees that are under some form of stress. The *Armillaria* species on the dry, eastern side of the Cascade Mountains in Washington are generally more aggressive and can cause patches of tree mortality.

In 2009, conifer susceptibility trial plots were installed near Glenwood, WA. The site is infested with both Annosus and *Armillaria* root disease. This project was described in the Annosus Root Disease section.

Figure 43. Above: *Armillaria* mushrooms at the base of a tree. Below: *Armillaria* underneath bark of tree.

Laminated Root Rot (*Phellinus sulphuracens* Pilát and *Phellinus weirii* (Murr.) Gilb.)

Laminated root rot is a native root disease in Washington. Most conifers are susceptible to laminated root rot, but some species are more susceptible than others. Douglas-fir is one of the most susceptible species in western Washington, while hardwoods can not be infected. The disease spreads from roots to roots in infested stands and can cause mortality in trees of all sizes and ages. When infected trees die or are cut, the fungus may continue to live for decades in colonized stumps. If seedlings of susceptible species are planted near previously infected stumps, they are very likely to get infected.

Foliar Diseases

Swiss Needle Cast (*Phaeocrytopus gaeumannii* (Rohde) Petrak)

Washington DNR

Figure 44. Swiss needle cast infected tree with thin crown and low foliage retention.

Figure 45. Healthy (upper) Douglas-fir needle and Swiss needle cast infected (lower) Douglas-fir needle.

Swiss needle cast (SNC) is a native foliar disease of Douglas-fir caused by the fungus *Phaeocryptopus gaeumannii*. Swiss needle cast affects only Douglas-fir and occurs throughout its range in western Washington. The disease is common on sites with abundant spring and/or summer precipitation and where mild winter temperatures favor the growth and reproduction of the pathogen. Trees with SNC may exhibit chlorotic (yellowing) foliage, premature needle loss, thinning crowns and reduced growth. Tree mortality from SNC is rare. The Washington aerial survey records very little area affected by SNC (37 acres in 2009) because symptoms are not evident during the summer flight season.

On the ground surveys have been conducted since 1999 to monitor incidence and severity of SNC in western Washington. Average incidence (the percentage of infected trees per site) ranged from 0-100% across the study sites between 1999 and 2009 (Figure 46).

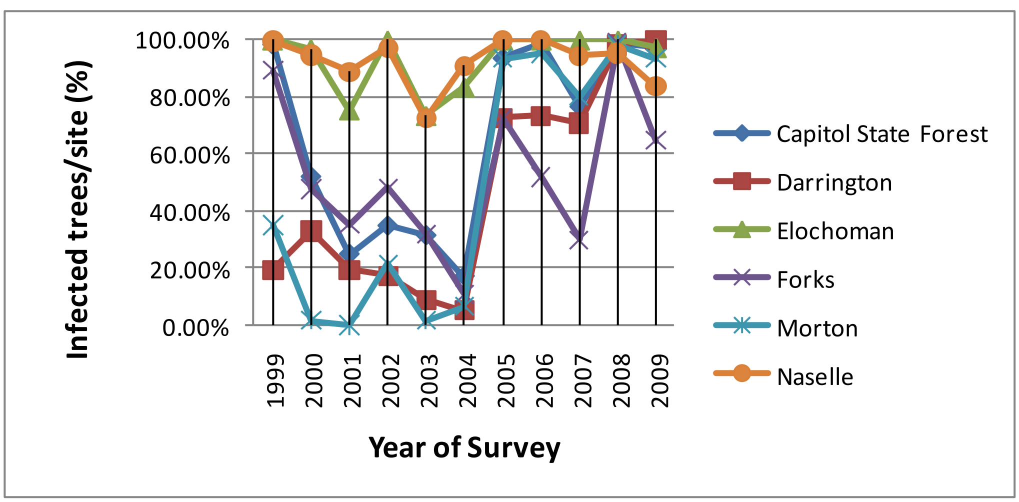


Figure 46. The incidence of SNC across six study sites in western Washington. The average percentage of trees infected with Swiss needle cast at each site, each year.

Average severity (the percentage of stomata occluded by fungal pseudothecia in one-year old needles) ranged from 0-21% across the six study sites between 1999 and 2009 (Figure 47). In Washington, highest severity was at the Naselle site in 2005 at 21%. All other severity percentages were less than 16%, with 75% of the sample points (survey sites and survey years) having severity percentages below 5%.

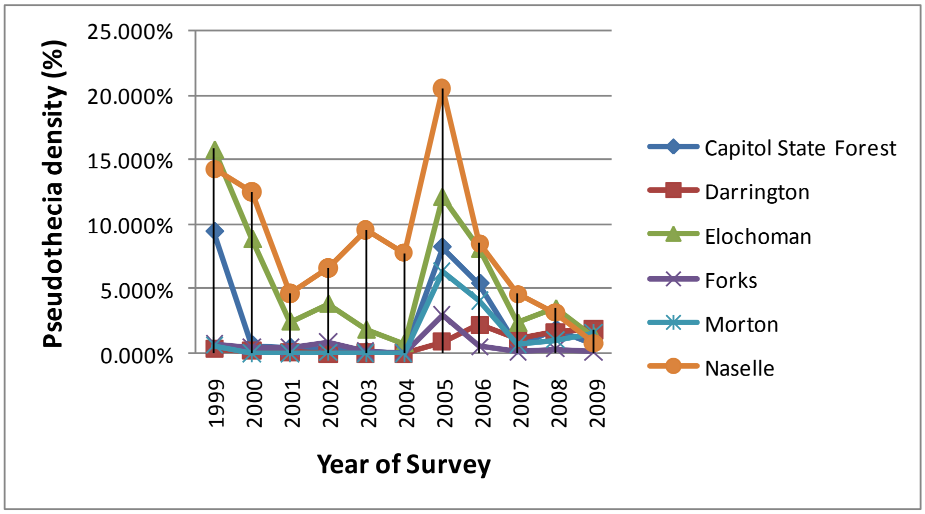


Figure 47. The severity of SNC across six study sites in western Washington. The average number of pseudothecia on each needle per tree per site.

Studies in Oregon involving SNC have shown that average respiration rates are reduced in trees infected with SNC beginning when about 25% of the needle stomata are occluded by fungal pseudothecia (Manter et al. 2003) and that needle abscission, or needle loss, can occur when about 50% of the stomata are occupied (Hansen et al. 2000). Reductions in the assimilation of carbon due to reduced respiration rates and complete needle loss can result in an overall decline in the growth rates of moderate to severely SNC infected trees. More work is needed to determine growth loss in forest stands in southwest Washington, where pseudothecia densities are the highest. However, if the Oregon standards are used, SNC appears to currently be having little impact on respiration or needle loss in one-year old needles in the Washington study sites.

Other Diseases

Sudden Oak Death (*Phytophthora ramorum* Werres & de Cock) NON-NATIVE

Phytophthora ramorum is the causal agent of Sudden Oak Death (SOD), ramorum leaf blight, and ramorum dieback. Western Washington is at risk for SOD due to the presence of known *P. ramorum* hosts in the natural environment, suitable climatic conditions (extended periods of moist weather and mild temperatures), and the presence of nurseries receiving positively identified *P. ramorum* host stock. In Washington, Sudden Oak Death mortality or damage are unlikely to be recorded using aerial survey methods because *P. ramorum* symptomatic plant material is currently undetectable from the air. Therefore, on the ground monitoring and survey projects are conducted to track the disease.

Amy Ramsey-Kroll, Washington DNR

Figure 48. Stream baiting trap with native rhododendron leaves inside.

Aquatic monitoring and forest and nursery perimeter surveys have been conducted in Washington since 2003, with efforts since 2006 focusing on aquatic areas near previously reported positive *P. ramorum* nurseries. The first *P. ramorum* positive sample in the Sammamish River, King County, WA, was found in April, 2007. In 2007 and 2008, through collaborative efforts among the WA Dept. of Natural Resources, the WA Dept. of Agriculture and USDA Forest Service, two more positive samples were found in the river. During that time twenty-two stream baiting traps were placed in the Sammamish River and two separate streamside vegetation surveys were conducted in order to search for the origin of the *P. ramorum* inoculum. All vegetation samples collected were negative for *P. ramorum*.

In 2009 stream baiting continued in Washington, with traps placed at 51 water courses entering into the Sammamish River. Positive *P. ramorum* samples were obtained from nine stream baiting sites. Landscape vegetation surveys and riverside vegetation surveys were conducted and soil samples were collected to try and determine where the inoculum was originating from. All samples from the vegetation surveys and the soil were negative for *P. ramorum*.

Amy Ramsey-Kroll, Washington DNR

Amy Ramsey-Kroll, Washington DNR

Figure 49. Sammamish River (left) and positive *Phytophthora ramorum* trap location (circled) on the Sammamish River (right).

Seventeen positive *P. ramorum* samples have been collected through stream baiting traps in the Sammamish River since January, 2009, but no diseased plants associated with these detections have been found (Figure 50). The source of the Sammamish River contamination continues to be under investigation.

In Pierce County in 2009, for the first time in Washington, it was determined that *P. ramorum* escaped the confines of a nursery and infected a wild salal plant nearby. Detection and eradication of all infected materials continues.

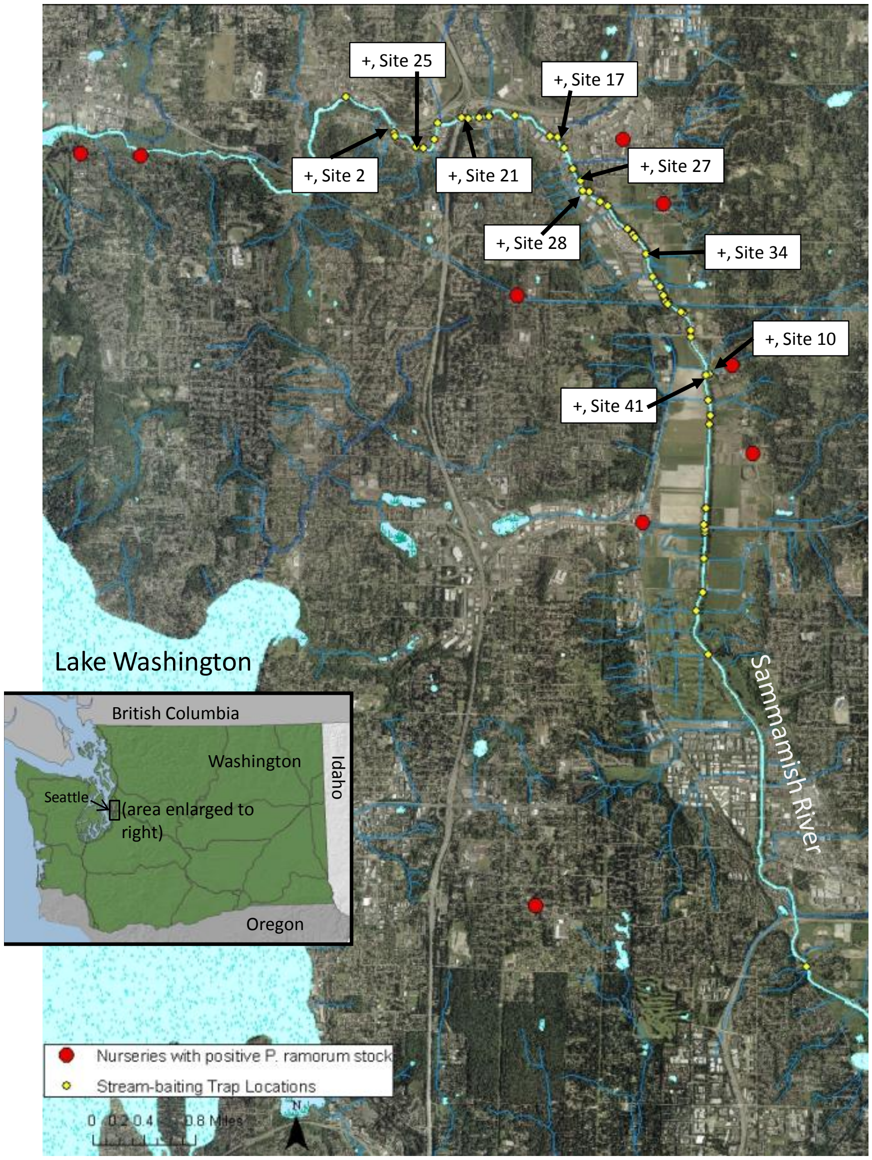


Figure 50. Map of Sammamish River area, including stream baiting trap locations, locations with positive *Phytophthora ramorum* samples and locations of nurseries that have received positive *P. ramorum* stock in the past.

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Data and Services

Every year, all forested acres in Washington are surveyed from the air to record recent tree damage. This aerial survey is made possible by the cooperation of the Washington Department of Natural Resources and the USDA Forest Service. It is very cost effective for the amount of data collected. These maps are great tools for a quick look at what forest disturbance events are taking place in your neck of the woods. They also produce excellent trend information and historical data.

Digital information: Draft survey maps can be downloaded as PDF files almost as soon as they are flown. They are available through a nationwide geospatial portal at: http://svinetfc8.fs.fed.us/aerialsurvey/Default.aspx?tabid=42. Click on the "Insect & Disease Detection Survey DRAFT 2009" button. Then click the farthest right icon (picture of an envelope) above the map to "Create Map Tile as PDF." Click "OK" then click the quad map you want to download. Enter your email address, then click "Send."

When traditional insect and disease survey quad maps are finalized, they are available for download as PDF files from 2003 to 2009 at: http://www.fs.fed.us/r6/nr/fid/data.shtml. Click on the year of interest under "Traditional Insect & Disease Maps."

For cartographers and GIS users, current and historical survey spatial data are available as downloadable ZIP files from 1980 to 2009 at: http://www.fs.fed.us/r6/nr/fid/as/index.shtml Washington DNR also maintains downloadable GIS datasets, including the most recent aerial survey data, known as "Bugs n Crud" at:
http://www.dnr.wa.gov/BusinessPermits/Topics/Data/Pages/gis_data_center.aspx.

In addition, our cooperative annual forest health highlights reports are available online at: http://www.dnr.wa.gov/ResearchScience/Topics/ForestHealthEcology/Pages/rp_foresthealth.aspx. These reports are published annually and include the latest information on exotic pest problems, insect and disease outbreaks, and recent forest damage trend information for Washington. Our 2009 update will be available on this website soon. Historic highlights reports for Oregon and Washington are available at: http://www.fs.fed.us/r6/nr/fid/pubs.shtml.

Major insect and disease identification and management information, illustrations, and graphical trend analysis of Pacific Northwest forest health issues are available at: http://www.fs.fed.us/r6/nr/fid/index.shtml.

The "Field Guide to Diseases and Insect Pests of Oregon and Washington Conifers," produced by the USDA Forest Service Northwest Region, is a great reference for anyone wanting to learn more about forest pests in the Pacific Northwest. You can obtain a copy by calling toll free (866) 720-6382 or ordering it online at: http://bookstore.gpo.gov/actions/GetPublication.do?stocknumber=001-000-04731-1.

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